

Remarks

Claims 1-5 are pending in the application. In response to Applicants' 16 March 2005 amendment and request for continued examination, the previous rejections of the claims over Rice (U.S. Patent No. 6,310,619) were withdrawn and new grounds for rejection have been asserted. Through the arguments below that traverse the new grounds for rejection, the patentability of the presently claimed invention is established.

I. Objections to the Drawings

The Office Action Summary (Form PTOL-326) indicates that the drawings filed on 28 April 2001 have been objected to by the Examiner, but the Detailed Action does not describe the deficiencies found in the drawings. Applicants respectfully note that formal drawings were submitted in this case on 25 July 2001.

II. Claim Rejections Based Upon Cited Reference

- (a) Claims 3-5 were rejected under 35 U.S.C. §102(e) as anticipated by Ross et al. (U.S. Patent No. 6,608,628, hereinafter "Ross"), and claims 1-2 were rejected under 35 U.S.C. §103(a) as obvious over Ross.
- (b) Applicants note, as a first matter, that Ross was issued on 19 August 2003, *after* the 28 April 2001 filing date of the present application, and after the 28 April 2000 filing date of the provisional application (Ser. No. 60/200,407) to which the present application claims priority. Thus, Applicants reserve the right to explore the possibility of "swearing behind" Ross's earliest effective filing date of 06 November 1998 in an affidavit under 37 CFR §1.131.
- (c) The presently claimed invention relates to software development of general haptic virtual environments, which can include creation or importation of a three-dimensional graphical virtual environments. The presently claimed invention (hereinafter, the "G2H" system or invention) permits generation of a user selected size and shape of a three-dimensional model to be used as a

proxy in order to represent the haptic device in the computational virtual space. This is important since otherwise there is no way of seeing what is being touched in the physical virtual device workspace by the haptic device. This is a crucial mapping of the correspondence needed between the physical virtual device workspace in which the haptic device is physically moved and the computational virtual space containing the virtual scene with virtual objects. From software development point of view this means that the graphical representation of the cursor also needs to be addressed. This would require additional code if G2H is not used. In fact, the scene graph (containing objects) with the cursor and the tissue textures applied to the objects all require additional programming to generate the new haptic virtual environment, even if the graphical environment is already present.

(d) All of the pending and rejected claims (1-5) include the limitation *creating a cursor with attributes of movement within multiple layers*, which, the instant Action asserts is taught by Ross at col. 9 lines 33-35, figs. 9A-B, and col. 11, lines 20-64. Applicants respectfully assert that this is a misreading of Ross.

First, the Action implies that an object created by Ross has multiple layers. Section III of Ross that describes CYBERSCALPEL (col. 8, line 32 to col. 11, line 19, especially col. 9 lines 14-42) and that relates to Fig. 8 discloses a method of using the virtual cutting tool with flat bones (col. 3, ll. 53-54, col. 9, ll. 14-15). Cutting flat bone creates inner and outer layers for the cut piece, however, Ross discloses connecting the layers to create a 3D solid with no objects inside. (col. 9, ll. 29-42, Figs. 9A-D; col. 10, ll. 15-20) Thus, Ross cannot logically cannot *create a cursor with attributes of movement within multiple layers* of graphic display to create or modify one or more virtual objects, since such a cursor would need to be created inside a virtual object. This is in contrast to the presently claimed invention, supported by Applicants' specification Figures 4 and 5, wherein multiple layers, with each layer representing a surface of an object that may be inside (i.e., within) another (outer) object. In the exemplary Figure 5, it can be seen that the inner layer actually represents a completely different object. The virtual human breast object

(outer layer) includes a tumor (inner layer) as an inner object that is independently represented and can be touched through the breast. Ross therefore fails to teach or suggest this limitation and the present invention as recited in claims 1-5.

Secondly, with respect to the Action's assertion that col. 11, ll. 20-64, discloses creating or modifying one or more virtual objects "in real-time by using the force-feedback (haptic) devices and technology", Applicants again respectfully disagree with the conclusion reached. The virtual collaborative clinic component (VCC) of Ross patent is a networking component that enables multiple users to interact in real-time with the same stereoscopic 3D data set that is generated by the Mesher and the Cyberscalpel (see the last five lines of the Abstract; Figs. 2, 12A-B, 13-15, 18; col. 4, ll. 55-58; col. 5, ll. 18-27; col. 10, line 36 to col. 11, line 2; col. 11, line 20 to col. 16, line 53; and specifically col. 11 lines 22-25) It is unclear how reference to the VCC leads to the conclusion stated. The only remotely related element Applicants can identify is that of simultaneous viewing. The presently claimed invention does allow viewing of four different views simultaneously, however, the VCC of Ross simultaneously distributes the same single view of an object being manipulated to geographically distributed users (Figs. 1, 5, 9A-D, 11A-E) but does not provide a user interface with four different simultaneous views. Applicants fail to comprehend the VCC's relevance to the pending patent claims, since the presently claimed invention is not directed to networking at all.

Another significant limitation present in claims 1-5 and not taught or suggested by Ross is that a *user can create said haptic virtual environment without writing any computer code*. For example, once a poly-mesh based graphics virtual environment exists (again, Ross teaches how to create such an environment for solid 3D, but not *multi-layered* objects), code will need to be generated for developing the haptic processing to make the graphics objects touchable. This code typically includes: (1) acquisition of physical properties of the objects; (2) modeling these properties into a set of variables to be used by the haptic processing engine so the objects can be touched and felt realistically; (3) interface to algorithms for collision detection and computing

force feedback; (4) creation of a 3D object to be used as a symbolic representation, a cursor, for the tip of the haptic device position in the virtual space; (5) initialization of the servo loop of the haptic device; (6) interface the haptic device to the virtual environment; (7) creating a homeomorphism between the physical work space, that is used to move the tip of the haptic device, and the virtual work space; (8) development of inter-process communication and feedback loop synchronization between the graphic (either mono or stereoscopic executing at usual rates of 30Hz or 60Hz) and haptic (executing usually at 1000 Hz) processes; (9) applying the computed force feedback to the haptic device; and (10) testing and modifying the virtual environment to ensure real-time stability of the created haptic objects. It is through this applied force to the haptic device that a user holding the device feels the physical properties of objects being touched.

The presently claimed Graphics-to-haptics (G2H) tool, as described in Applicants' specification, provides a framework for developing such stable haptic applications. The G2H uses a real-time visual software development process to automatically convert multi-layers of poly-mesh objects into haptic objects with no additional programming (needed for these steps 1-10). The G2H automatically extracts information from poly-mesh objects (e.g. geometry, visual properties, positions and orientations) in order to construct the *haptic scene graph* and to make the objects in the scene graph touchable. A default haptic texture consisting of physical properties such as stiffness, damping, and static and dynamic friction is initially applied. The G2H provides a material editor that can generate or modify haptic textures while permitting to incorporate new set of properties. Users can interactively modify the values of the properties for the textures and save them into a library. Objects feel different as soon as new or modified haptic textures are applied to objects.

(e) The Action also asserts that col. 11, ll. 20-64, discloses creating or modifying one or more virtual objects "in real-time by using the force-feedback (haptic) devices and technology." The cited section includes the following text:

“The VCC component 22 (FIG. 2) is an extension of the reconstruction unit 21 that generates a virtual environment that enables multiple users to interact in real-time with the same stereoscopic 3D data set. One advantageous use for such a system is to examine 3D reconstructions of medical data for consultation and diagnosis by medical practitioners who are located in different parts of the world. Thus, the VCC environment is particularly suited to displaying 3D models of anatomical reconstructions used in medical diagnoses and treatment planning, and the collaborative aspects allow physicians at different geographical sites to manipulate these objects as though looking at a common display.”

Little to none of the remote interaction and networking capabilities of the VCC appear to be directly related to the presently claimed haptic virtual environment tool. Col. 11, ll. 20-25 describes that the VCC component enables multiple users to interact in real-time with the same stereoscopic 3D data set, and thus considers only the visual (and thus only graphics) aspect of the virtual environment. No consideration of the haptic aspect is provided. The cited section of Ross includes the sentence “Development of a virtual environment, imaging and the force-feedback (haptic) devices and technologies will make it possible to send sonically scanned data back to Earth for *visualization*, when necessary.” This is the only reference to “haptics” in Ross, and notably it is referenced only with respect to visualization and not for the sense of touch, as in G2H. Ross is devoid of any disclosure relating to the development of haptic virtual objects such as algorithms required for collision detection or for generating the force-feedback. It is essential to address such issues in creating complex and precise haptic virtual objects that provide a realistic sense of touch (as discussed on page 3, paragraph 5 of Applicants' specification.)

Note that in the software development process, the haptic virtual environment is created independently of its graphics representation, as described in the paper “Development of Stereoscopic-Haptic Virtual Environment” incorporated by referenced in Applicants' specification. The collision detection and force feedback computation algorithms required for graphics and haptics integration process are addressed on page 3, paragraph 5 of Applicants' specification. Note also that there is a distinction between Ross' VCC technologies that make it possible to remotely network for visualization, and “*haptics*” that provide a calibrated sense of

touch using a force-feedback (haptic) device. Haptic devices, as used in Applicants' application, refers to a device providing feedback that is proportional to the properties of virtual objects being modeled. The presently claimed invention makes it possible to differentiate tissue properties of computer generated objects, a feature that makes the additional complexity of the software worthwhile. Ross fails to teach or suggest feeling the objects existing in a virtual environment.

Thus, Ross teaches attributes only for the purpose of *visualization*. The instant applications' physical properties and haptic attributes (e.g., stiffness, static and dynamic friction, etc.) are important in producing a sense of touch in the virtual objects. (see Fig. 1; page 2, par. 2; page 6, par. 18; page 7, par. 19; page 7, par. 21; page 8; par. 23.) Such attributes are not addressed anywhere in Ross. Modeling these *physical properties* into a virtual environment require completely different software development techniques compared to modeling visual attributes. Being able to apply these physical properties and their variations in real-time using the G2H interface software makes it possible for us to "to create one or more virtual objects in real-time by using the force-feedback (haptic) devices and technology."

The Action also asserts that Ross teaches *selecting a virtual object with said cursor*, citing col. 11, ll. 20-64 describing the VCC. As noted above, Ross does not provide a method of creating *haptic virtual objects*. It is respectfully submitted that selection of Ross' objects with a cursor, or placement of the cursor on the objects, do not make the objects haptic. The mention in Ross of a cursor is at col. 6, ll. 17-20, regarding the pointing device 36 of Fig. 3. The only use of Ross' cursor is to indicate a specific location within the image of the 3D object displayed on a monitor. Thus, Ross fails to teach or suggest selecting any object, haptic or graphic, with a cursor. In contrast, in the presently claimed invention the cursor embodies a means for interfacing, initializing, and using a haptic device. (see Fig. 5; pars. 16, 18 and 19.) Applicants' 3D *cursor* is created as a symbolic representation for the position of the tip of the haptic device in the virtual work space that corresponds to the position of the tip of the haptic device. In Figure 5, the cylinder is an embodiment of a cursor. With the G2H user-interface, any 3D object can be

selected as a cursor (see par. 19.) As the haptic device moves in the physical space, so does the cursor in the virtual space. If the cursor occupies the same position as one of the virtual objects in the haptic scene, a collision has occurred. At this point a user has touched the virtual object and the haptic process provides a force feedback to the user via the haptic device. At this point a user can feel the physical properties (such as smoothness, hardness, etc) of the virtual object as if it was real. It is in this sense that the presently claimed invention can *select a virtual object with the cursor*. This transformation of the graphics virtual object into a touchable (haptic) virtual object is processed through a code module of G2H and thus does not require writing additional code.

Ross' cursor does not represent the tip of a haptic device. Rather, the word "cursor" is used in its common meaning of a pointer overlaying a graphical image, and since it has no connection to haptics, there is no discussion of collision detection or computing force feedback.

(f) With respect to claim 5, paragraph 19 of Applicants' specification reads: "The user creates a cursor and selects an object. The user places the cursor name in the text dialog box and activates a "get cursor" command button. The object selected appears in the "Object Properties List Box" where the user can select and modify each object by providing means for creating a volumetric 3D object with internal layers. The user can modify the surface stiffness and/or add static and dynamic surface friction to any of the layers. In this way a volumetric object is created which provides for a realistic touch so that when the user activates the haptic device button, the user can "feel" the object." This paragraph describes a method of assigning and *changing the physical attributes* of the *layered objects* within the virtual environment. Note that when the graphics scene contains only solid objects, the same method is used to manipulate the physical attributes of these solid objects. The textures and the shapes of the objects being felt are based on the physical properties applied to them and the shapes of the objects themselves. This method of assigning and changing the physical attribute that creates *plurality of virtual objects*, as any

change in a physical property makes the object feel different. Ross does not disclose applying and modeling the physical properties of virtual objects.

(g) With respect to claims 3-5 (and in a similar manner claims 1-2), the Action asserts that col. 11, ll. 35-43 of Ross teaches “modifying a surface stiffness of one or more layers of said poly-mesh form (by using the force-feedback devices to interact with the virtual object.” Applicants can find no disclosure in Ross of haptic objects of any kind (nor even a single 3D solid haptic object), much less the process of creation of haptic objects. Ross therefore has no need to address issues of applying any physical properties such as *surface stiffness* or *static and dynamic friction* which are inherent to haptics. These concerns are not considered anywhere in Ross. The Action appears to base the rejections on the assumption that Ross teaches haptics, however this is simply not the case. Ross does disclose creating a graphics virtual environment with 3D solid objects (represented as poly-mesh) and sharing it collaboratively with multiple users. Ross, however, describes only graphic attributes of objects, and not physically based properties of haptics, such as *surface stiffness (or static and dynamic friction)*. Integration of these attributes requires very different techniques.

(h) The comments above with respect to Ross' failure to teach or suggest the limitations related to *...providing a haptic virtual environment... a cursor with attributes of movement within multiple layers... means for creating, modifying and saving haptic properties of said one or more virtual objects...without writing any computer code* are equally applicable to a discussion of claims 1-2, and are thus not repeated here.

With respect to claim 1, the Action additionally asserts that the limitation *...means for generating a haptic representation of said one or more virtual objects directly from graphical representation of said one or more virtual objects, wherein said one or more virtual objects comprise a plurality of layers that are represented by a three-dimensional poly-mesh form* is

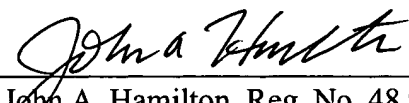
disclosed by Ross' MESHER, discussed at col. 6, ll. 43-65, and col. 11, ll. 20-64, and illustrated in Figs. 5 and 9A-D. Applicants respectfully disagree. Ross discloses in MESHER a means to generate surface models of 3D objects, represented by poly-mesh, and thus graphics 3D solid objects from a volumetric image data set, and provides a means for cutting an object and connecting the outer and inner surfaces (termed layers) of the same object to convert it to a 3D solid object. This is not the same concept as layers created by individual independent poly-mesh objects inside another, as recited in claims 1-2. In Applicants' system, a layer representing an object also has outer and inner surfaces.

(i) In light of the foregoing, Applicants respectfully submit that Ross fails to teach or suggest the inventive methods recited in claims 1-5, and therefore request reconsideration and withdrawal of both the §102(e) and §103(a) rejections of said claims. Applicants respectfully submit that claims 1-5 are now in a condition for allowance, and a notice to that effect is earnestly solicited. If any questions arise during the review of this amendment/reply, the Examiner is invited to contact the undersigned at (617) 854-4000 to discuss any issue.

Respectfully submitted,

BHARTI TEMKIN, et al.,
Applicants

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By: 
John A. Hamilton, Reg. No. 48,946
Attorney for Applicants